FIELD MONITORING

Caltrans Storm Water Monitoring Techniques

Caltrans

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- Pat-Chem Laboratories
- RBF

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Presentation Agenda

- Purpose of Monitoring
- Sample Representativeness
- Siting
- Planning and Logistics
- Equipment Selection and Installation
- Sampling and Analysis

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Why Monitor?

- Permit Requirements
- Total Maximum Daily Loads (TMDLs)
- California Toxics Rule (CTR)
- Litigation-driven Projects
- Research
  - Characterization Studies
  - BMP Pilot Studies

Fundamental goal of gathering additional and supporting information

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Definition

- Selected/Collected from the Population
- Measures that are
  - Precise
  - Accurate
  - Reliable
  - Valid
- Defined Differently Depending on Agency/Organization
  - Event Mean Concentration
  - First-flush grab

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Sample Representativeness

Definition

Must Consider:

- General Characteristics of Aqueous System
- Flow Modes
  - Intermittent
  - Highly variable
  - Base and peak flows
  - Hydrology and hydraulics
- Variability of Constituent Concentrations
  - Time (e.g., first flush, whole event)
  - Cross-section (e.g., turbulent/laminar flow, velocity, density, lateral dispersion, stratification)

So that accurate conclusions or inferences can be made about the population

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Sample Types

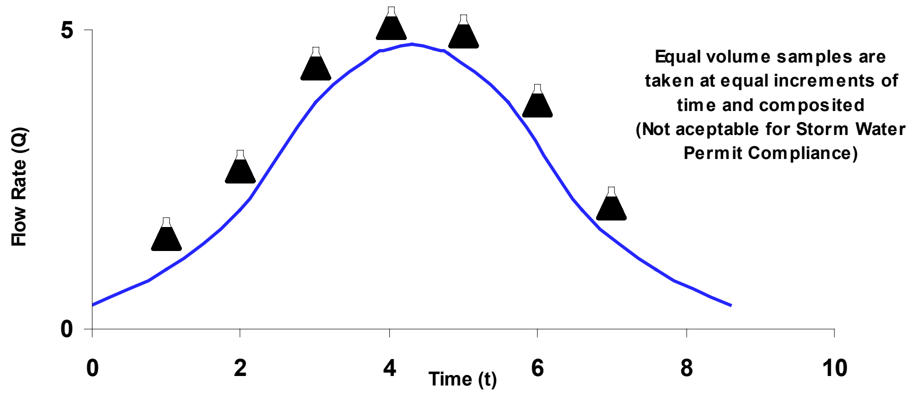
Grab Sample: A discrete individual sample taken within a short period of time (usually less than 15 minutes)

Composite Sample: Sample comprised of a series of individual aliquots that have been combined to reflect the event mean concentration (EMC) during the sampling period

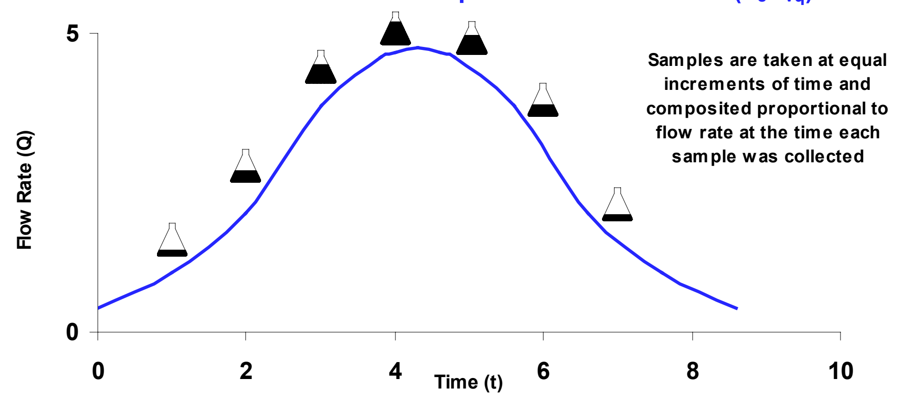
Sample Representativeness

Composite Sample

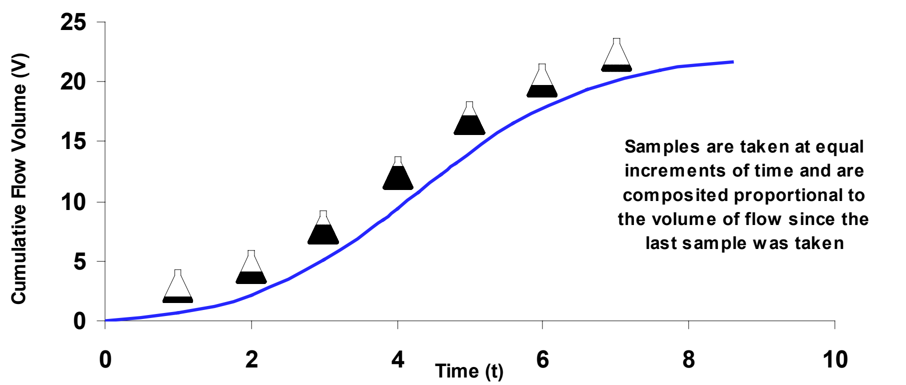
Constant Time - Constant Volume (T_cV_{cv})



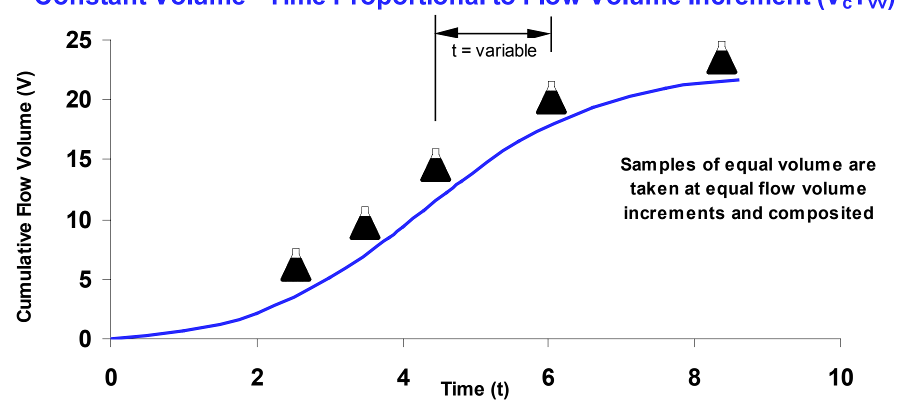
Constant Time - Volume Proportional to Flow Rate (T_cV_{vq})



Constant Time - Volume Proportional to Flow Volume Increment (T_cV_{vv})



Constant Volume - Time Proportional to Flow Volume Increment (V_cT_{vv})



Typical Caltrans Criteria

- Representativeness
- Personnel Safety
- Site Access
- Equipment Security
- Flow Measurement Capability
- Electrical Power and Telephone
- Non-Caltrans Sources

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Common Challenges

- Unsafe access to site
- Flow does not concentrate or can not be rated
- Commingling with other runoff sources
- Lack of space to house equipment
- Sites are relatively small and have small t_c resulting in
  - low runoff volume
  - short periods of runoff

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Common Challenges

- Freeway characteristics and bad driving habits affect monitoring
  - call box locations with soft shoulders become depressed
  - gopher holes cause flow bypass
  - trees shadow solar panels and rain gauges
  - drivers travel on shoulders
- Future construction precludes long-term data collection
- Monitored construction sites are dynamic
- Snowfall regions complicate site access and monitoring

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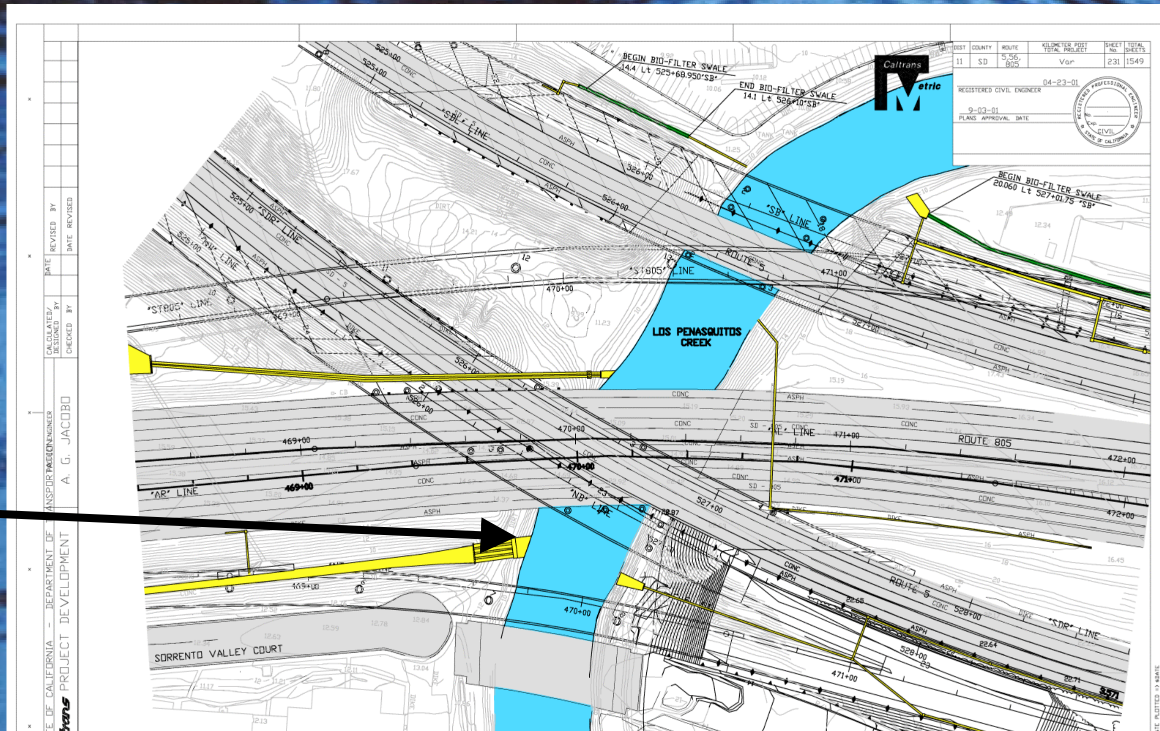
Siting

Solutions

- Develop project-specific siting criteria
- Use existing data when available
  - as-builts
  - photographs/video
  - local knowledge
  - GIS



Incomplete Plan for Design Study Only

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Solutions

- Plan on spending time in the field
- Check for accidents and crime with local agencies
- Check to see if construction is planned within the watershed
- Coordinate permitting early on
- Look for sites that are greater than 1 acre
- Look for sites that can be accessed away from traveled way
- Look for sites where flow concentrates
- Check watershed for offsite runoff contribution

Solutions

- Look for multiple monitoring locations at construction sites
- Avoid conveyances with steep slopes (>5%)
- Avoid sites with gopher activity
- Avoid sites near call boxes
- Avoid sites where there is evidence of vehicles travelling off pavement
- Avoid sites near trees

Planning and Logistics

- Trained Staff
- SAP
- Laboratories
- Sample Bottles and Tubing
- Weather Tracking
- Storm Selection Criteria
- Equipment Programming

It pays to plan!!

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Trained Staff

- Conduct field training prior to each season
- Maintain a core group of team leaders
- Have a large staff pool available
- Follow-up any missed events with team

Sampling and Analysis Plan

- Project Description, Organization, and Responsibilities
- Monitoring Site(s)
- Analytical Constituents
- Data Quality Objectives (DQOs)
- Field Equipment Maintenance
- Monitoring Preparation and Logistics
- Sample Collection, Preservation, and Delivery (40 CFR 122.21/122.26)
- Quality Assurance/Quality Control
- Laboratory Sample Preparation and Analytical Methods (40 CFR 136)
- Data Management and Reporting Procedures
- Appendices:
  - Clean Sampling Techniques and Equipment Cleaning Protocols
  - Health and Safety Plan (HSP)

A Sampling and Analysis Plan is a must!!

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Laboratories

- Inform lab of QA/QC requirements (e.g., DLs)
- Establish reporting requirements and formats early on
- Look for labs that are available 24/7
- Look for full-service lab
  - bottle and tubing cleaning
  - customized coolers
  - compositing
  - splitting
  - QA/QC

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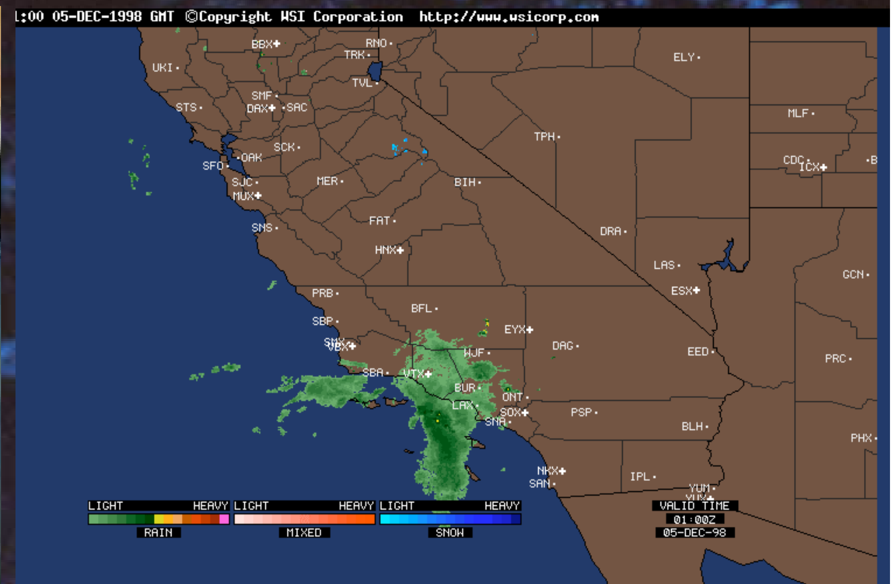
Laboratories

- Expect to work closely with lab
- Keep the lab informed of upcoming events
- Keep track of samples and when results are expected
- Provide lab adequate time to re-supply bottles, etc.

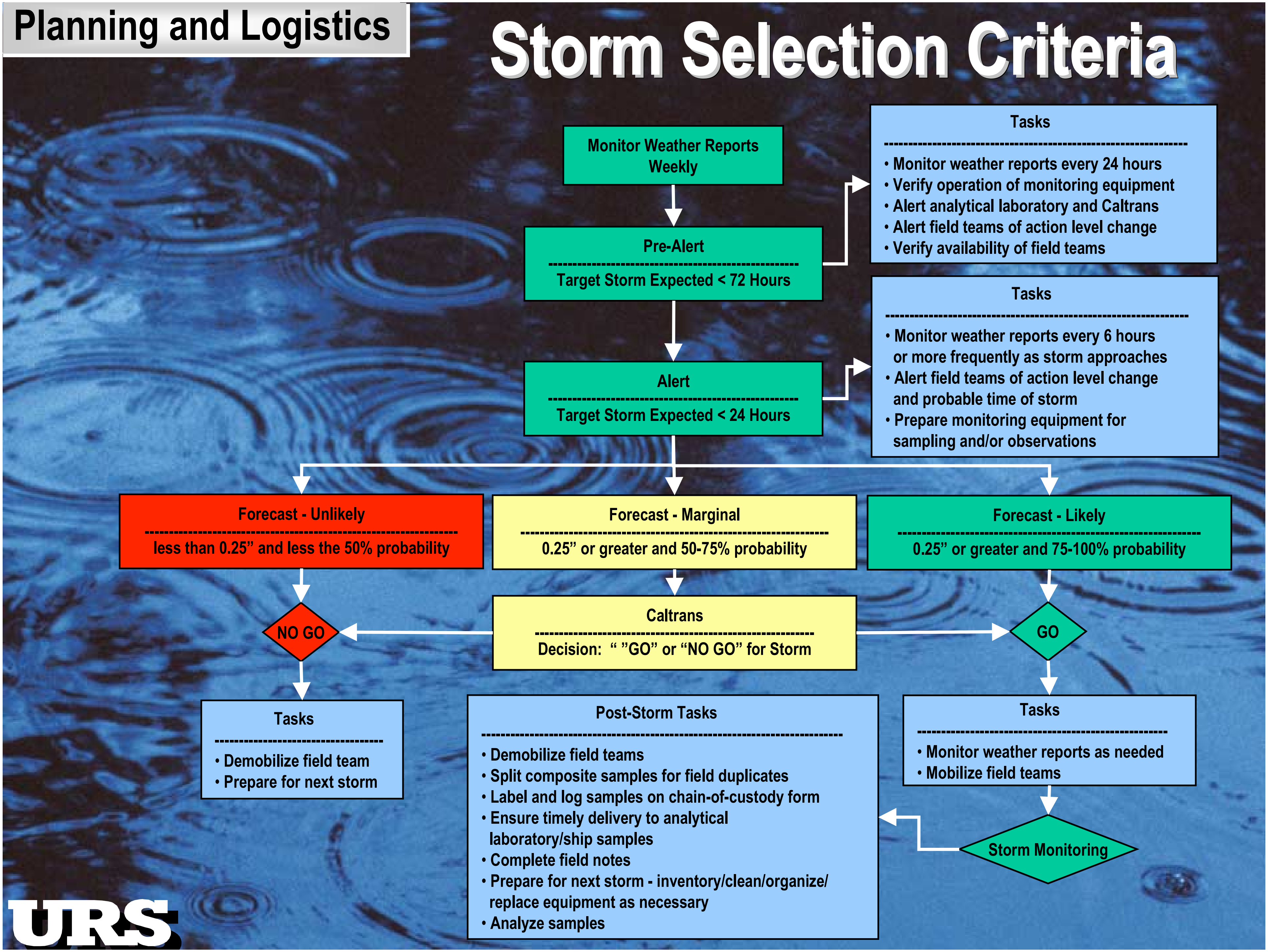
Sample Bottles and Tubing

- Must be chemical resistant
- Material won't contaminate sample
- Teflon and borosilicate glass are acceptable
- Decontamination performed by lab
- Blanking required to confirm equipment is "clean" before use
- Extra bottles for back-to-back events
- Custom coolers to prevent bottle breakage

Weather Tracking



- Unlikely Storm Event
- Marginal Storm Event
- Likely Storm Event
- WILD CARD



Planning and Logistics
Storm Selection Criteria
Monitor Weather Reports Weekly
Pre-Alert
Target Storm Expected < 72 Hours
Tasks
• Monitor weather reports every 24 hours
• Verify operation of monitoring equipment
• Alert analytical laboratory and Caltrans
• Alert field teams of action level change
• Verify availability of field teams
Alert
Target Storm Expected < 24 Hours
Tasks
• Monitor weather reports every 6 hours or more frequently as storm approaches
• Alert field teams of action level change and probable time of storm
• Prepare monitoring equipment for sampling and/or observations
Forecast - Unlikely
less than 0.25” and less the 50% probability
Forecast - Marginal
0.25” or greater and 50-75% probability
Forecast - Likely
0.25” or greater and 75-100% probability
NO GO
Caltrans
Decision: “ ”GO” or “NO GO” for Storm
GO
Tasks
• Demobilize field team
• Prepare for next storm
Post-Storm Tasks
• Demobilize field teams
• Split composite samples for field duplicates
• Label and log samples on chain-of-custody form
• Ensure timely delivery to analytical laboratory/ship samples
• Complete field notes
• Prepare for next storm - inventory/clean/organize/ replace equipment as necessary
• Analyze samples
Tasks
• Monitor weather reports as needed
• Mobilize field teams
Storm Monitoring
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Equipment Programming

Sampler pacing based on:

- Predicted rainfall
- Tributary area
- Runoff coefficient
- Number of aliquots
- Required sample volume

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Equipment Programming

Challenges:

- Predicted rainfall not accurate
- Tributary area not precisely known
  - inaccurate as-builts
  - sub-basin crests not determined
- Runoff coefficient “C” varies
  - storm size
  - storm duration
  - rainfall intensity
  - antecedent dry period
  - published values of C based on 5- to 10-year storm events
  - infiltration/ponding through pavement cracks, seems, depressions
- Small watersheds
  - short runoff periods
  - limited runoff volume
- Sample aliquot collection rate (typically 2 to 4 minutes)

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Equipment Programming

Solutions:

- Don't rely on one forecast…use many sources
- Program equipment based on last possible QPF
- Survey the watershed
- Verify tributary area during rainfall by observing flow patterns/paths
- Track runoff volume per depth of rainfall
- Visually evaluate and integrate antecedent conditions into runoff volume estimates
- Target fewer sample aliquots (i.e., increase sampler pacing and aliquot volume) for
  - small watersheds
  - short duration events
  - small storms

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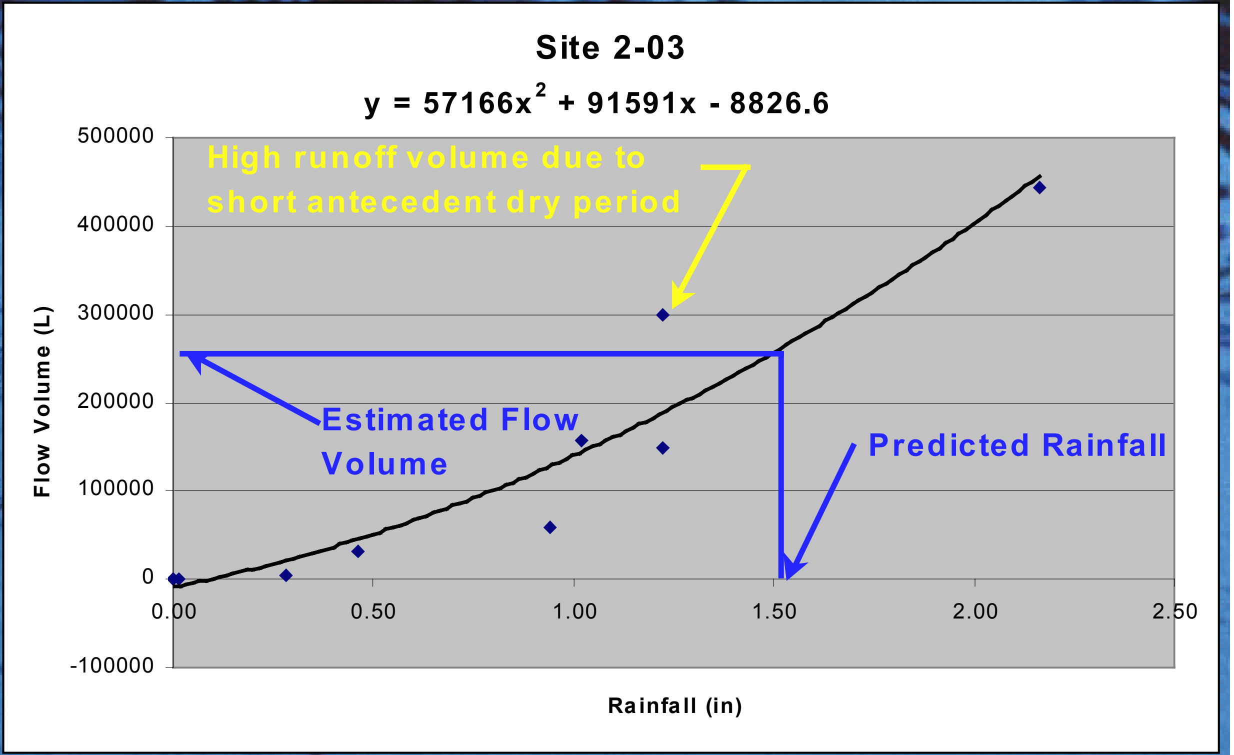
Equipment Programming

Solutions:

- Target maximum number of aliquots to fill sample bottle
- Recognize that a shake-out period during initial storms may be required
- Mobilize field teams to change out bottles if rain or runoff exceeds forecasts

Herbert S. Miles Rest Area	2-03
Rain (in)	Flow (L)
0.94	58822
0.46	31198
0.00	0
0.28	5549
0.01	0
0.00	0
1.22	149382
2.16	444225
1.22	298682
1.02	157888
QPF (in)	1.5
Forecasted Volume (L)	257183
Volume-to-Sample (L)	7144



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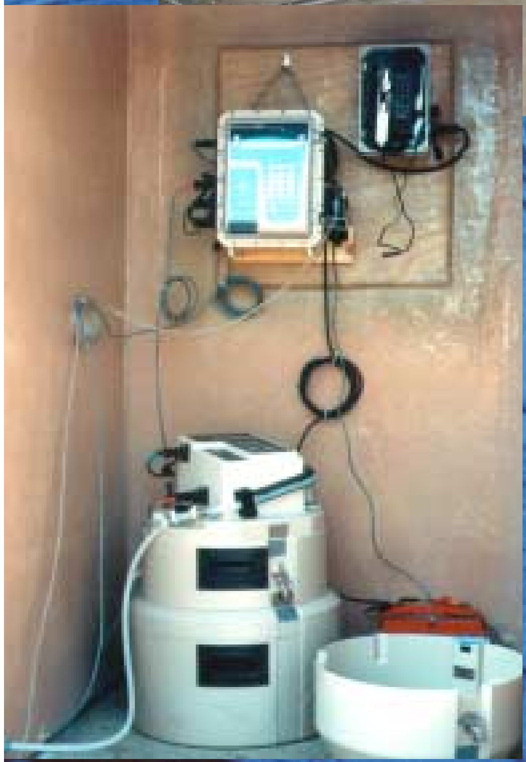
Automated Sample Collection



- Technique for “unattended” sampling
- Requires:
  - intensive planning
  - careful monitoring point selection
  - appropriate equipment selection
  - QA/QC
- Consider discharge homogeneity:
  - physical
  - chemical
  - biological

Don’t be fooled…auto samplers are not fully automatic!!

Automated Sample Collection

Challenges:

- Faulty electronic and physical components
- Limited suction lift
- Improper installation and programming
- Improper sample intake positioning
- Limited/constrained intake and transport velocities
- Sample volume deviations
- Unable to sample low flows

Equipment Selection and Installation

Automated Sample Collection

Challenges:

- Intake blockage and line plugging
- Tubing distortion and kinks
- Tubing wear
- Sampling stagnant water
- Tubing damage by rodents
- Insufficient number of aliquots
- Insufficient % storm capture
- Sampler can't keep up with pacing

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Automated Sample Collection

Solutions:

- Follow manufacturer's instructions
- Work closely with manufacturer
- Double-check connections
- Check for no air bubbles in tubing
- Locate intake away from high sediment areas
- Maintain an upward sweep of sampling tube from intake
- Encase tubing in conduit
- Ideally use auto samplers where discharge velocity equals sample intake velocity

Automated Sample Collection

Solutions:

- Remove sediment from around intake before storm events
- Locate intake downstream of confluence in well mixed zones
- Position intake in straight line of conveyance
- Position intake at point of maximum turbulence
- Use intakes with orifices large enough to draw in largest particle
- Use intakes with orifices small enough to assure adequate transport velocity

Automated Sample Collection

Solutions:

- Direct intake into flow ± 20 degrees
- Use low-flow intakes for shallow flows
- Minimize cross-section exposure of intake to limit conveyance obstruction
- Minimize vertical distance from sampler and intake (20ft max)
- Minimize tubing length
- Calibrate sample volume
- Carefully estimate expected storm volume

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Equipment Selection and Installation

Flow Measurement

- Necessary to collect representative flow-weighted composite sample
- Used to calculate mass loading
- Used to assess rainfall/runoff relationship
- Primary device accuracy dependent on:
  - selection of device
  - care of fabrication and installation
  - calibration and analysis
  - proper operation with adequate inspection and maintenance
- ± 5% accuracy under ideal conditions
- ± 10% accuracy typically obtained in field when properly constructed calibrated and maintained

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Flow Measurement

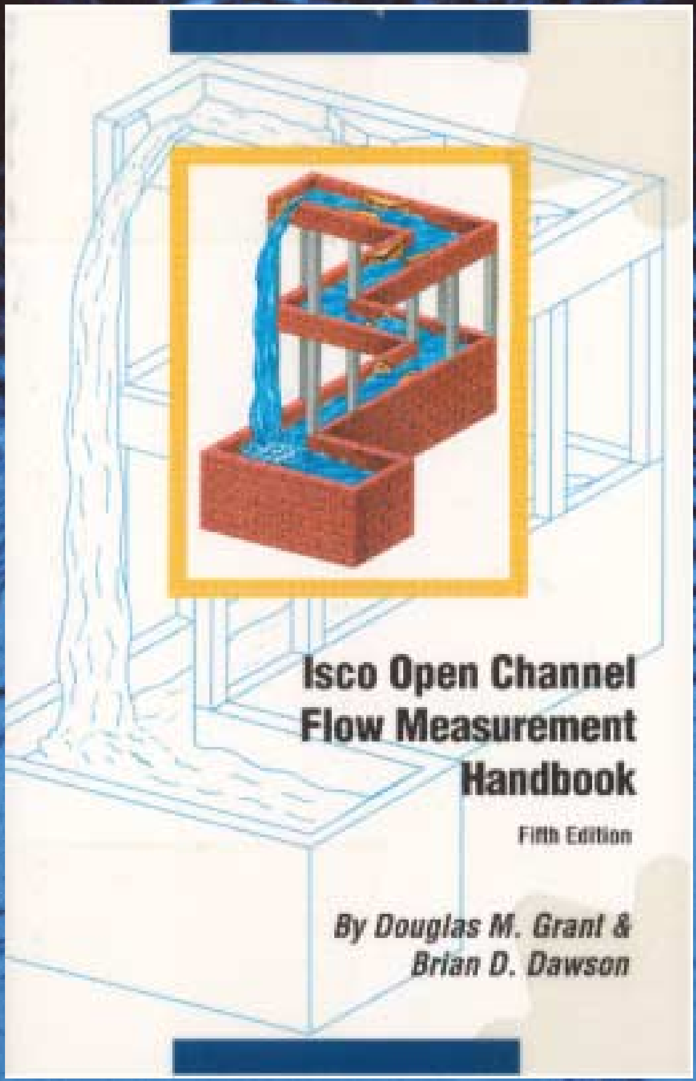
Challenges:

- Low flows (depth and velocity)
- Flow meter probe covered with sediment
- Flow meter probe covered with ice
- Uniform flow not established in existing conveyance
- Corrugated metal pipe ridging causes turbulence
- Poor mass balance between influent and effluent BMP Pilot monitoring stations
- Some primary devices cause excessive upstream ponding
- Backwater condition exists at monitoring location

Flow Measurement

Solutions:

- Device Selection
  - Use primary devices where possible
  - Use AV bubblers when backwater conditions exist
  - Select device that is accurate over range of expected flows
  - Select device that can be installed in the conveyance
  - Select device that is appropriate for location (e.g., power, submersible, etc.)
  - Work closely with equipment manufacturer
  - Use similar device upstream and downstream of BMP Pilots
  - Avoid flumes that cause ponding water upstream
  - Purchase pre-fabricated primary devices



Equipment Selection and Installation

Flow Measurement

Solutions:

- Installation:
  - Avoid sites with sediment deposits
  - Install at location where flow is laminar
  - Install flumes to allow free-flowing water
  - Fix leaks or bypasses
  - Squarely install and level primary devices
  - Make sure all connections are tight
  - Calibrate

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Flow Measurement

Solutions:

- Field Evaluation:
  - Look for excessive flows submerging device
  - Look for flows outside of accuracy range
  - Repair leaks and/or bypasses
  - Minimize turbulence
  - Remove any solids accumulation and obstructions
  - Check that correct factor/formula is used to convert head to flow rate
  - Visually check head measurements and compare with flow meter readings; level adjust if necessary

Sampling and Analysis

Challenges:

- False events
- Collecting representative TSS data
- Temperature extremes
- Equipment failure
- Verifying data is representative

False Events

Solutions:

- Carefully evaluate site hydrology
- Develop mobilization criteria
- Use multiple forecast sources
- Wait until last possible moment to make mobilization decision
- Budget for false events

TSS Samples

Solutions:

- Sample from well mixed zone
- Avoid locations that can block intake
- Properly position sample intake
- If possible, capture all runoff and sediment (mass-balance approach)
- Analyze sample using Suspended Sediment Concentration (SSC) analysis ASTM D 3977-97

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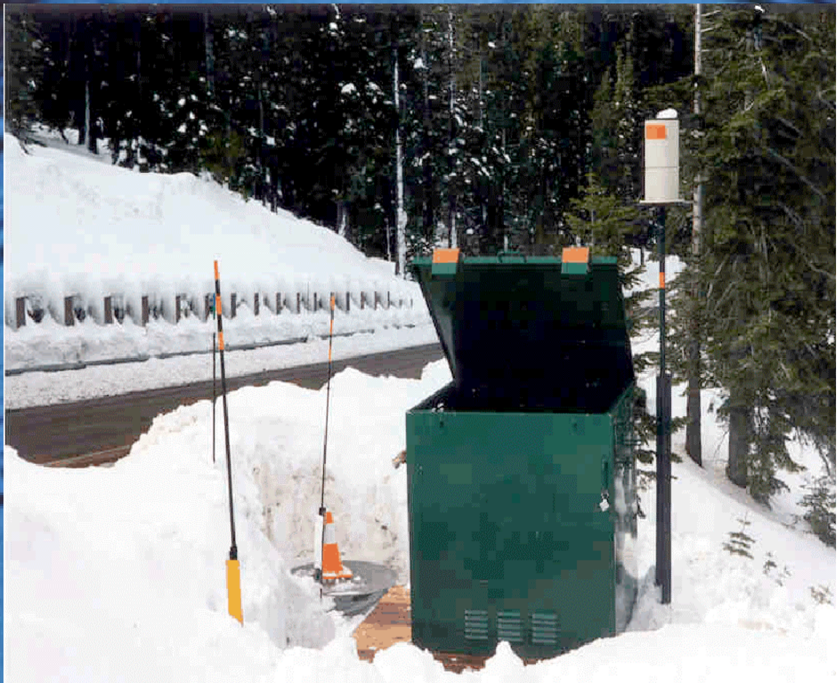
Temperature Extremes

Solutions:

- Use metal housings and place in open areas in cold environments
- Insulate enclosures and tubing
- Maintain an upward sweep of sampling tube from intake
- Remove icy buildup around probes and strainer prior to each event using warm water
- Use heated rain gauges
- Obtain rainfall data from NWS or affiliate
- Forecast temperature so that snowmelt can be predicted
- Mark equipment for snow maintenance crews
- Remove equipment from enclosures during summer months



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Equipment Failure

Solutions:

- Perform pre-storm maintenance and calibration
- Be onsite during events
- Have backup batteries on hand
- Perform real-time trouble-shooting
- Use 24-hour technical support services
- Document and inform staff of lessons-learned
- Segregate faulty equipment
- Purchase backup equipment

Expect to have equipment failure…electronics and water don't mix!!

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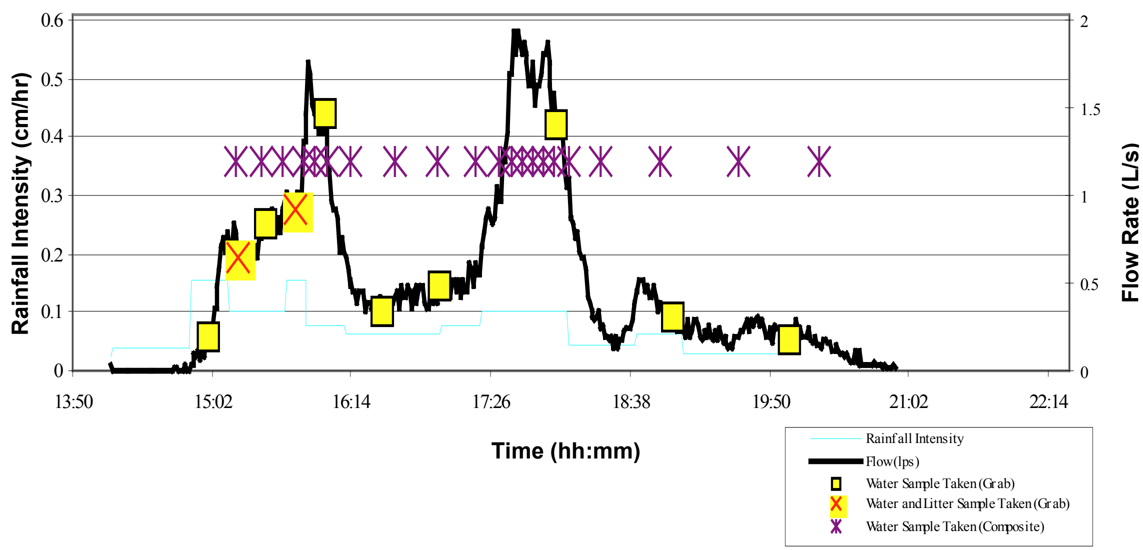
Verify Data Representativeness

Solutions:

- Evaluate storm total
- Evaluate number of collected aliquots
- Evaluate sample history
- Evaluate % storm capture
- Review event hydrograph and hyetograph
- Collect QC samples
  - Field Duplicates
  - Laboratory Replicates
  - MS/MSDs
  - Blanks
- Adhere to holding times
- Validate data



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Questions/Answers